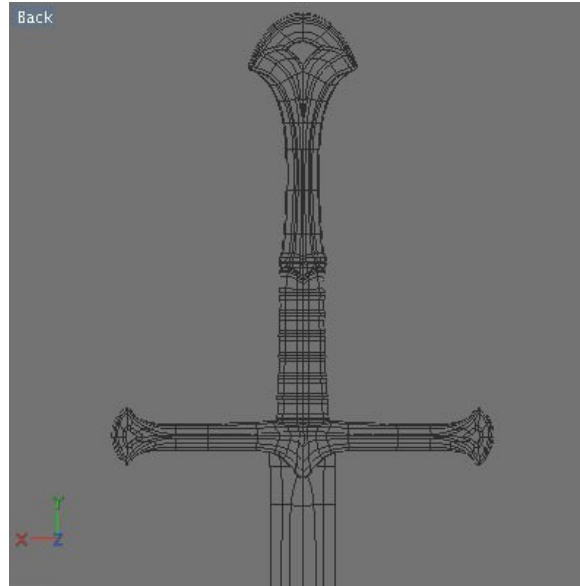


The American PDW

Building the American Carbine

10mm Blowback Bolt Weight Calculations (Blowback)



Blowback Firearms: Theory & Practice

Below: MAC-10/45 Standard Bolt Assembly



Below: MAC-10/45 Bolt with Weight for Katana



Massive bolt addition used to harness the 10mm in blowback

Reproduced from the Website “Orion’s Hammer”

“Most high-powered guns have a locking bolt, where locking lugs hold the chamber closed during firing. This includes bolt-action or break-action rifles, as well as rotating-bolt semiautos like the AK or AR. “Blowback” guns, by contrast, just use the inertia of the bolt to hold the chamber closed. Here’s a schematic view of a blowback gun, from George Chinn’s 1955 masterpiece, “The Machine Gun”, volume 4, part X. This is a public-domain government publication, so I’m reproducing the figures here directly.

Blowback guns are actually a lot easier to build in a garage than locking bolt guns, because:

There are no mating or rotating parts; in fact, the only moving part can be the bolt!

You don’t need to machine locking lugs into the bolt or chamber.

There is no “headspace”, or cartridge slop before the bolt hits the locking lugs.

The force on the bolt face is mostly just compression, instead of the tension at the back of the lugs (see Dan Lilja or Varmint AI for locking bolt analysis). So you can build working blowback bolts from crappy materials like mild steel (of course, harder steel will wear better).

Blowback designs are legal in most US states, as long as you use a semiauto hammer or striker. The federal government forbids most use of open-bolt (fixed firing pin) designs, since they’re extremely easy to make fully automatic.

Case Head Separation

So why aren’t all guns blowback? Well, blowback guns do have this little tendency to explode if designed incorrectly. Also, after a certain power level, they weigh more.

Here’s a typical cartridge pressure curve. You can record your own pressure curve with a strain gauge like a Pressure Trace, but traces from different cartridges and guns are surprisingly similar, and different mostly in peak pressure (from about 10Kpsi to 60Kpsi).

pressure versus time curve for firearm chamber; peak at 1/2ms

The tens of thousands of pounds of pressure inside the chamber only last for a millisecond or two, and they're what push the bullet down the barrel.

chamber pressure pushes bullet down the barrel

Note that the chamber pressure pushes back on the bolt with the same pressure that it pushes the bullet down the barrel. This is bad, because if the bolt moves back under pressure, then the cartridge tends to stretch out. If it stretches too far, the case head may separate from the body of the case, and spray hot gas at tens of thousands of PSI in all directions. This "case head separation" can and has killed people, for example by flinging the bolt at high velocity back through the shooter's eye.

Not good.

You can stop the case head from separating by:

Fluting the chamber, like the HK MP5 or G3, which equalizes the pressure inside and outside the chamber.

Greasing the cartridges, so the cartridge tends to slide out of the chamber instead of sticking to the walls. Chinn says heavy grease is needed; light oil tends to get squished off the high spots.

Pushing back against the case head with enough force. This force can come from tricky-to-machine locking lugs, but we'd like to just use bolt inertia.

Note that even a tiny 22 long rifle cartridge pushes on the bolt head with a force of about a thousand pounds, so you can utterly forget about springs (at least, any spring you could possibly cock by hand!), or friction, or magnets, etc.

That last point bears repeating. From the previously cited Chinn Vol 4, page 15 (underline added by me):

"NOTE: There is one point which requires special clarification at this time. In many descriptions of blowback actions, it is strongly implied that the driving spring contributes a substantial portion of the resistance which limits acceleration imparted to the bolt by the powder gases. Actually, this is not so. Although it is true that the driving spring absorbs the kinetic energy of the recoiling bolt and thus limits the total distance it moves, the resistance of the spring does not have any real effect in the early phase of the cycle of operation. The bolt acceleration occurs mainly while the powder gas pressures are high and are exerting a force of many thousands of pounds on the bolt. The driving spring, in order to permit the bolt to open enough to allow feeding, must offer a relatively low resistance. Although this resistance is sufficient to absorb the bolt energy over the comparatively great distance through which the bolt moves in recoil, it is not great enough to offer significant opposition to the powder gas pressure until the chamber pressure has dropped to a relatively low level well after the projectile has left the muzzle."

The myth that "a stronger recoil spring will prevent case head separations" persists on the internet to this day. This is a myth.

In any blowback design, you can reduce the chance of lethal injury after a case head separation by:

Venting the escaping gases out as wide an ejection port as possible.

Making the bolt's front face fairly small, so the escaping gases push on a smaller area.

Putting a very beefy rear trunnion at the end of the bolt's rearward travel to absorb the bolt's extra energy. This is over and above the normal recoil energy.

Not having loose parts near the chamber (e.g., sights, extractor gizmo) that could get blown off during an explosion.

Putting distance between the user and the chamber area. Forward-magazine pistols are good for this (chamber is well forward of the operator's hands), bullpup rifles are very bad (chamber is right next to the user's cheek!).

How Fast will the Bolt Move Back?

Here's how to figure out the forces acting on the bolt.

pressure pushes bullet down barrel and pushes bolt back

The same chamber pressure that pushes the bullet down the bore, pushes the bolt backwards. If the bolt weighed the same amount as the bullet, then it would fly back with bullet velocity, shooting the shooter! So our basic tool to keep the bolt velocity down is mass.

Chinn claims that, ignoring friction:

momentum of bolt = momentum of projectile + momentum of gas (+ momentum of barrel?)

$m_{\text{bolt}} * v_{\text{bolt}} = m_{\text{bullet}} * v_{\text{bullet}} + m_{\text{gas}} * v_{\text{gas}} (+ m_{\text{barrel}} * v_{\text{barrel}}?)$

For small cartridges like pistols, a typical charge weight is 3-6 grains of powder to push a hundred-something grain bullet, so we can usually ignore the momentum contribution of the gas. However, chamber pressure in any bottlenecked case pushes the barrel forward quite hard, so I don't think we can safely ignore the barrel's momentum like Chinn does.

The basic problem here is that though the pressure pushing the bullet and bolt are equal, the areas are not equal. Cartridges are always at least a little bigger at the back end, and sometimes much bigger. This causes "bolt thrust" issues with the new short fat cartridges like 300 WSM, even at quite reasonable chamber pressures. In fact, unlike Chinn, I'm going to ignore the gas momentum and start out by assuming:

pressure on bolt face = pressure on bullet back

Since pressure = force / area, the forces on the bolt face and bullet will differ by the ratios of their areas.

force on bolt face / area of bolt face = force on bullet base / area of bullet base

or

force on bolt face = force on bullet base * (area of bolt face / area of bullet base)

Now we're getting somewhere! Momentum is the integral of force over time (force is actually defined as the time derivative of momentum), so if we integrate both sides above by time (that is, integrate the pressure curve), then we get:

momentum of bolt = momentum of bullet * (area of bolt face / area of bullet base)

The area of a circle is of course $\pi * \text{radius}^2$, or $\pi/4 * \text{diameter}^2$, so this is equal to:

momentum of bolt = momentum of bullet * (diameter of bolt face / diameter of bullet base)²

We can easily look up the momentum of a fired bullet. If we scale that by the area ratio, we get the bolt's momentum. If we divide by the bolt weight, we get the bolt's velocity. If we divide by a target bolt velocity, we get the required bolt weight.

ASSUMING a 4m/s bolt velocity is safe, then the required bolt mass is:

bolt mass in pounds = $1.09 \times 10^{-5} \times \text{bullet mass in grains} \times \text{bullet velocity in fps} \times (\text{diameter of bolt face} / \text{diameter of bullet base})^2$

The conversion constant 1.09×10^{-5} comes from asking Google to express [1 grain * 1 foot/second / 4 m/s in pounds](#). Here's the above bolt mass figured for some common cartridges:

Cartridge	Bolt weight	Bolt thrust	Bullet	Velocity	Caliber	Base	Proof
	Unitspounds	Kpounds	Grains	Fps	Inches	Inches	KPSI
22lr	0.4	0.9	29	1240	0.223	0.224	31.2
32acp	0.8	1.8	71	905	0.312	0.338	26.7
38oacp	1.1	2.4	90	1000	0.356	0.374	28.0
38special	1.3	2.5	110	945	0.358	0.379	28.6
9×19 Parabellum	1.7	4.6	88	1500	0.355	0.391	50.1
7.62×25 Tokarev	2.0	4.0	87	1390	0.312	0.387	44.5
40s&w	2.2	4.9	135	1324	0.400	0.424	45.5
357magnum	2.2	5.0	125	1450	0.358	0.379	57.2
45acp	2.3	3.7	200	975	0.452	0.476	27.3
9x23winchester	2.4	5.4	125	1450	0.356	0.392	58.5
45colt	2.4	2.9	185	1100	0.456	0.480	20.8
45gap	2.5	4.1	185	1150	0.452	0.476	29.9
357sig	2.6	5.6	125	1368	0.355	0.424	52.0
10mm	2.8	5.3	170	1340	0.400	0.425	48.8
410bore	2.8	2.4	109	1755	0.410	0.478	17.6
30 carbine	3.2	4.0	100	2200	0.308	0.356	52.0
44magnum	3.8	5.9	210	1495	0.432	0.457	46.8
454casull	5.4	10.2	240	1916	0.458	0.478	74.1

500s&w	5.5	11.0	275	1650	0.500	0.530	65.0
50ae	6.0	8.1	300	1579	0.500	0.543	45.5
7.62×39	6.3	6.9	123	2350	0.311	0.443	58.5
6.8spc	6.6	8.2	85	2900	0.268	0.421	76.7
223 Remington	7.0	6.9	80	2869	0.224	0.376	80.6
30-30	7.2	6.4	150	2390	0.309	0.420	59.8
7.7arisaka	9.9	8.3	180	2200	0.311	0.473	61.1
45-70	9.9	6.4	400	1900	0.458	0.504	41.6
308 winchester	11.3	10.8	168	2680	0.308	0.470	80.6
8mm Mauser	11.8	9.9	198	2625	0.324	0.470	74.1
7.62x54R	12.2	10.5	180	2575	0.311	0.485	74.1
7mm Mauser	12.3	10.0	154	2690	0.285	0.472	74.1
50alaskan	12.6	8.3	450	2150	0.500	0.548	45.5
30-06	12.8	10.4	190	2700	0.309	0.470	78.0
375h&h	14.2	12.8	235	3000	0.375	0.513	80.6
300wsm	17.4	15.7	150	3300	0.308	0.555	84.5
300 winchester magnum	17.8	13.2	190	3150	0.309	0.513	83.2
338lapua	24.4	18.4	250	3000	0.338	0.587	88.4
300lapua	25.0	18.4	220	2910	0.309	0.587	88.4
50bmg	54.3	27.4	660	3080	0.511	0.804	70.2
20gauge	5.5	4.6	218	1800	0.615	0.699	15.6
16gauge	7.7	5.0	350	1600	0.662	0.746	15.0
12gauge	9.4	7.2	437	1600	0.729	0.812	18.2

10gauge	12.9	6.3	765	1280	0.775	0.855	14.3
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Here's the [Excel spreadsheet used above](#).

As a check, note that the blowback Ruger 10/22 bolt weighs 0.4lbs, exactly as predicted. Typical pistol-caliber submachinegun (SMG) bolts for 9mm, Tokarev, or 45acp are around 1.4lbs, although open-bolt SMG requires only half as much bolt mass (the chamber pressure has to slow down and stop the closing bolt before pushing it open again). Based on these calculations, which use “proofing loads” the 10mm in rifle form (a 170 bullet at 1800fps in a 16 inch barrel) would need 2.8 lbs to keep the breech safe at full power loads! This massive a bolt weight would have to be added to an existing design or made for a new design. For Anduril, the bolt weight is made by Lage Manufacturing. This allows either factory regular loads, with a somewhat lethargic bolt movement, or full power loads with no fear of early bolt opening. The bolt weight was originally made by Lage for slowing the MAC-10/45 full auto gun to slow their cycle rate to around 600 rpm. By luck, it also allows the use of 10mm if the weapon is set up correctly. I could even add additional weight by inserting Tungsten slugs in the bolt weight, just as a machine shop will add “Mallory Metal” to a crankshaft to balance it.

Note that most rifle cartridges would require an absurd bolt weighing over ten pounds (the 50bmg bolt weight would weigh over 50 lbs!). This is of course all ASSUMING the 4m/s bolt velocity is slow enough to prevent the case from exploding! The sole reason for this weight addition is to brake the bolt. High speed photography will determine if the theory bears out in fact.

The second column gives the peak-pressure force on the bolt, which is shown in **thousands** of pounds (Kpounds). The pressures used for figuring bolt thrust are proof loads, 30% over the maximum SAAMI or CIP pressure. These huge forces are the big thing complicating locking designs—the locking lugs have to be really tough!

The 10mm level of power really represents the upper level of the blowback action due to the necessary weight of the bolt. Any more power and the bolt becomes so massive that the weapon becomes cumbersome, the exact opposite direction we want to go. If we add a locking mechanism, the complexity of design goes up, again not the direction we want to go. The 10mm shows its excellence by delivering the most force out the barrel controlled by a bolt weight within a reasonable consideration.

ALL ITEMS DESCRIBED and their sources will be placed on a “Sources” page.

16 Responses to 10mm Blowback Bolt Weight Calculations (Blowback)



Jeff Hankonsilk says:

October 19, 2015 at 2:44 pm

All theoretical and not much relevancy in practice.

The 7.62 x 25 PPS43 bolt weighs only 560 grams, not 907 grams as the chart says it would.

Closed bolt variations are in fact lighter (more material milled out) and are certainly not doubled in weight.

The 9mm closed bolt micro UZI pistol bolt is just over 400g, not 770 grams as the chart says it would need to not blow up.

.. and then there's the 9mm MPA mini mac which has a tiny light bolt.

★ Like

[Reply](#)



Harry Brown says:

October 30, 2015 at 3:29 am

Hi Jeff! The 7.62 x 25 PPS43 with a 560gm bolt is an open bolt machine gun. As you have read in the pages, the weight only has to be half for an open bolt because a fixed firing pin bolt is flying forward, therefore the bolt must be brought to a halt and then accelerated backward, thus giving the time necessary for the bullet to exit the barrel.

I never said the gun would “blow up”, but that the bolt (depending on the chamber) would extract the case MORE than the 4m/s laid down in Chinn’s formulas. FA Mac’s typically run at over 1000 round per min and I am dealing with a cartridge that has just as much pressure as a 9mm and far more powder. I want to keep the case in the barrel as long as possible, thus I err to the maximum weight.

According to my barrel maker, a few people have tried to make a 10mm MAC before but “Didn’t like the results”. The stroke (distance between the rear of the frame and the rear of the bolt) is short that a lighter weight bolt smacks into the buffer in the back, causing the entire weapon to bounce around the CG (Center of Gravity) of the weapon, making it jump about.

Also, semi-auto MAC’s have a bad reputation of “bolt bounce”, meaning that they come all the way forward and then actually bounce back, opening the bolt with a live cartridge in the chamber. This happens so fast it does not matter to semi-auto guys, UNLESS they are trigger bouncing the gun to make it run like full auto. The extra caution I am going for here is adding weight is to also get rid of this inherent bounce. Different weight, different harmonics. Here is a video of a kid nearly wounding himself doing exactly this: <https://youtu.be/YTFriROpZUU>.

Here is a video of bolt bounce: https://youtu.be/4sPjrT_ZOTM

★ Like

[Reply](#)



Dogwalker says:

January 13, 2021 at 9:48 am

An Hi Point C9 (9mm blowback, closed bolt) slide only weights 524 grams and that is a weight of absolute safety, so much that Hi Point slides are heavily milled without problems.

Mind that, to be sold, factory slides had to be safe for shooting proofloads that develop 30% more pressure than standard rounds, and a 524 grams slide manages to do that (and with a wide margin of safety), Unfortunately that chart is completely off for any caliber bigger than .22 LR. No real blowback weapon use bolt weights that came even close to the ones listed.

★ Like



Dogwalker says:

February 2, 2021 at 3:35 pm

To give another example, the slide of a .45 ACP Hi Point (again, closed bolt) weights 751 grams instead of the 1134 grams indicated. That’s 34% less (as for 9mm, from 771 to 524 grams is 33% less).

Bill Holmes in “Home Workshop prototype firearms” indicates in 284 grams and 340 grams the absolute minimum required bolt weights for 9mm and .45 acp (Thus he probably didn’t keep proofloads into account).

★ Like



snalblog says:

November 30, 2015 at 4:13 pm

the weight only has to be half for an open bolt because a fixed firing pin bolt is flying forward, therefore the bolt must be brought to a halt and then accelerated backward, thus giving the time necessary for the bullet to exit the barrel.

yes but... in case of hang fire, the bolt act like if it was fired in closed bolt mode.

★ Like

[Reply](#)



Storm says:

March 28, 2016 at 11:14 pm

“Weight only has to be half” – This is false assumption and is based on advanced primer ignition that occurs in specially designed automatic cannons, and not in the pistol caliber weapons. “Article” author calculated some things good, but also made some mistakes and ended up with a theory that should not be considered as an axiom (which is understandable since apparently he is not a scientist-but that is overlooked) .What is unfortunate that gun related talks and topics are infested with copy paste of said text, and I believe that it actually discouraged gun designers in using it, rather than promoting blowback as a brave new method.

The whole chart is way too heavy.

★ Like

[Reply](#)



Subgunner says:

April 20, 2016 at 5:45 pm

1. Automatic cannons are not blow back. They are locked breech.
2. The theory is Chinn's, the go to source for information on designing machine guns since the 1950's.
3. The chart, as stated, is centered around the “Proof” rounds, not the standard cartridges used everyday.

★ Like

[Reply](#)



Storm says:

December 22, 2017 at 12:00 pm

1. You need a lot of research to do:

https://en.wikipedia.org/wiki/MK_108_cannon

★ Like



Dogwalker says:

January 19, 2021 at 3:34 pm

One of the most succesfull 20mm AA cannons ever, still currently used, blowback action.

https://en.wikipedia.org/wiki/Oerlikon_20_mm_cannon

★ Like



chonkus says:

July 15, 2023 at 12:41 am

the guys commenting on your post are stupid, both the weapons they talked about use long chamber, so yes they are straight blowback but they have an extended chamber to allow for power to drop, i personally find your chart very helpful and have built 1 pistol and 1 rifle based on your research, keep it up!!!

★ Like



Jason says:

August 2, 2016 at 8:02 pm

You mention magnets on here as a method not to use for locking a breach and I concur but have you considered a fully magnetic bolt surrounded by an aluminum tube? The aluminum tube interferes with the magnetic field causing an eddy current thus increasing the inertia of the bolt without increasing the weight. Just look up magnet falling through aluminum pipe on you tube.

★ Like

[Reply](#)



pacman10101 says:

May 3, 2020 at 2:04 am

I doubt an iron magnet would have much of an effect, and something like a neodymium magnet would be far too brittle to make a magnet out of
an insert floated between two springs might work

★ Like

[Reply](#)



Craig says:

June 29, 2020 at 3:04 am

I'm trying to make a pistol that's built like a rifle, but put into a similar stock as a flintlock, this is very useful

★ Like

[Reply](#)



pacman10101 says:

August 18, 2021 at 9:09 pm

what?

★ Like

[Reply](#)



Tony says:

February 15, 2021 at 5:08 am

Thanks for the details in this article. I read it with great interest in the hope of solving a problem with a transferable open bolt submachine gun chambered in 45ACP. The Spitfire was originally a 16" barreled rifle which ran well. After shortening the barrel about 50% the gun won't run – suffering from weak extraction and ejection. Trying all known tuning to correct the problem has failed. My current theory is that the shorter dwell time with the original bolt weight is the problem. Your formulas don't address dwell time. Can you please share your thoughts about removing weight from the bolt to run reliably in full auto in a shorter barrel? Thanks in advance for your help.

★ Like

[Reply](#)



Rand *says:*

October 2, 2024 at 1:07 pm

The link to the excel spreadsheet is very broken. I know it's an old link, just letting you know.

★ Like

[Reply](#)

The American PDW